SHALLOW SEISMIC REFLECTION INVESTIGATIONS OF THE BIG CREEK FAULT ZONE AND ITS EXTENSION INTO THE MEMPHIS, TENNESSEE, AREA: COLLABORATIVE RESEARCH WITH MISSISSIPPI MINERAL RESOURCES INSTITUTE, UNIVERSITY OF MISSISSIPPI

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Investigations Undertaken

Determining the location, style, and timing of surface/near-surface structural deformation in the Lower Mississippi Valley (LMV) is very important for evaluating earthquake hazards. Shallow seismic [both compressional (*P*-wave) and shear (*S*-wave)] reflection profiling has been the primary method used to identify, characterize, and evaluate the significance of surface/near-surface tectonic deformation in the LMV. The Big Creek Fault Zone (BCFZ) has been recognized and studied for over 50 years, although little detailed work regarding its geologic framework and potential earthquake hazard has been done. Short S-wave seismic reflection profiles were collected across the Big Creek escarpment (eastern Arkansas) to test the potential for S-wave techniques to image shallow deformation. The interpreted seismic profiles show that this topographic feature is underlain by high-angle faults that extend upward into Quaternary sediments (shallower than ~50 m). The structural style of the faults, and warping of shallow reflectors, indicates compression and suggests that the faults may have been reactivated as reverse or transpressional faults in the LMV's contemporary (east-west compressional) stress field.

This research will further investigate the shallow geologic structure of the BCFZ using 1) an S-wave seismic reflection profile collected over a section of the Big Creek escarpment with an uncertain origin, and study the possible extension of the BCFZ into the Memphis metropolitan area using 2) land- and 3) river-based P-wave seismic reflection methods. Integration of the seismic reflection data produced by this three-phase research project will allow a detailed evaluation of potential earthquake hazards associated with near-surface faults of the BCFZ.

Preliminary Results – Big Creek Escarpment Seismic Profiles

As part of an undergraduate geology research project at Millsaps College, a 135-m-long S-wave reflection profile (BC-1) was shot across a section of the northeast-southwest trending Big Creek escarpment, southwest of Helena, Arkansas (see Figure 1 for location), to test the potential for S-wave techniques to image shallow deformation along the BCFZ (Berman and Harris, 1998; Harris et al., 1998; 2000). The reflection data were collected in SH mode (sensitive to horizontally polarized shear waves) on a 12-channel engineering seismograph. The active spread consisted of 12 receivers (30-Hz horizontal geophones oriented perpendicular to the seismic line) spaced at 3-m intervals. The seismic profile was shot off-end with 3-m shotpoint spacings and a 3-m source offset. Seismic energy was generated by five horizontal impacts of a 4.5-kg sledgehammer on a 10-kg steel I-beam oriented perpendicular to the spread. Acquisition parameters on the seismograph included filter settings of 25 Hz (lowcut) and 250 Hz (highcut), a one-second record length, and a one-millisecond sampling interval. Processing followed a standard sequence for shallow common-midpoint (CMP) reflection data and included trace editing, bandpass filtering, and automatic gain control. The seismic data were stacked as a 6-fold section and, because there was significant topography along the profile, special care was taken with elevation statics and velocity analysis.

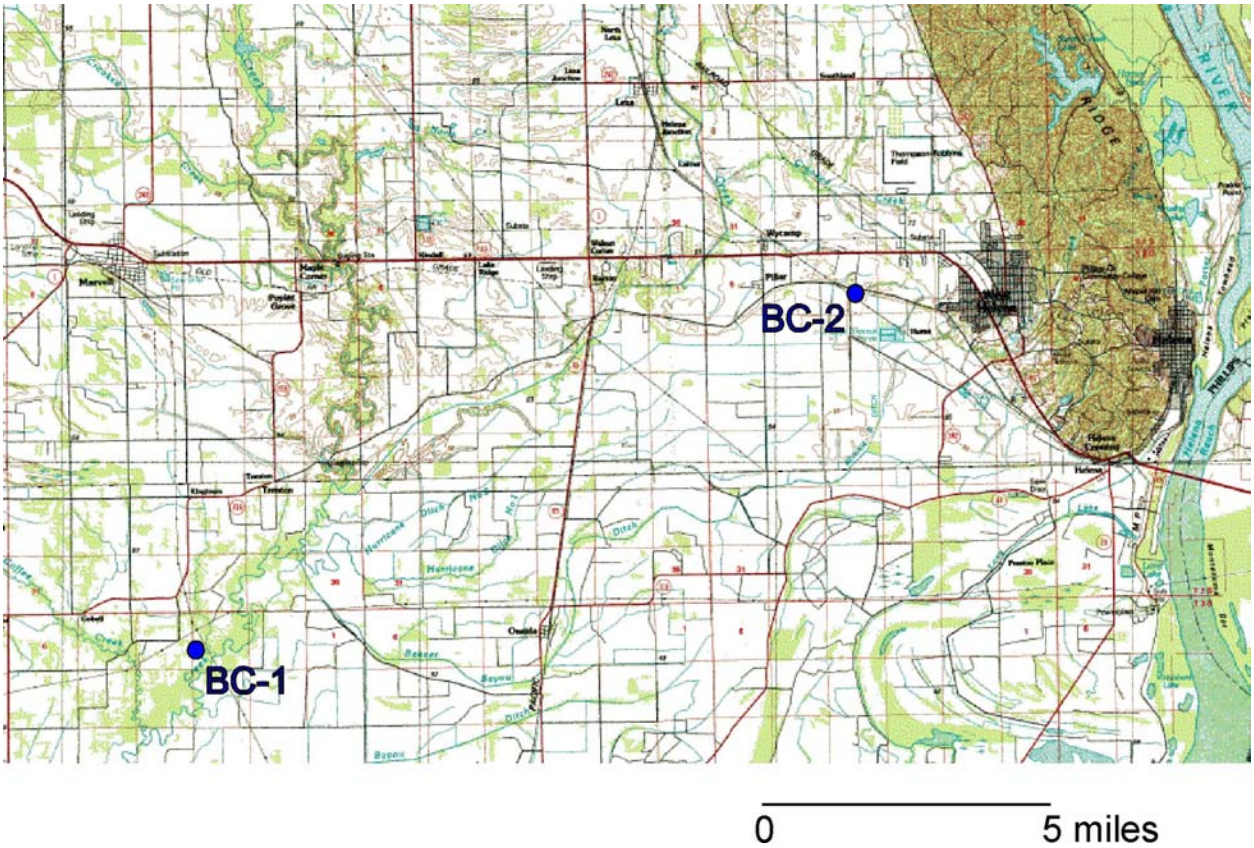

Figure 1. Map of the Big Creek escarpment in the vicinity of Helena, Arkansas, showing the locations of shear-wave seismic reflection profiles BC-1 and BC-2.

The interpreted seismic reflection profile across the Big Creek escarpment (Figure 2) shows that the scarp is underlain by high-angle faults, with a principal fault extending upward into Quaternary sediments (shallower that 45 m). Warping of shallow reflections indicates compression and suggests that the principal fault has been active as a reverse or transpressional fault in the LMV's contemporary (east-west compressional) stress field.

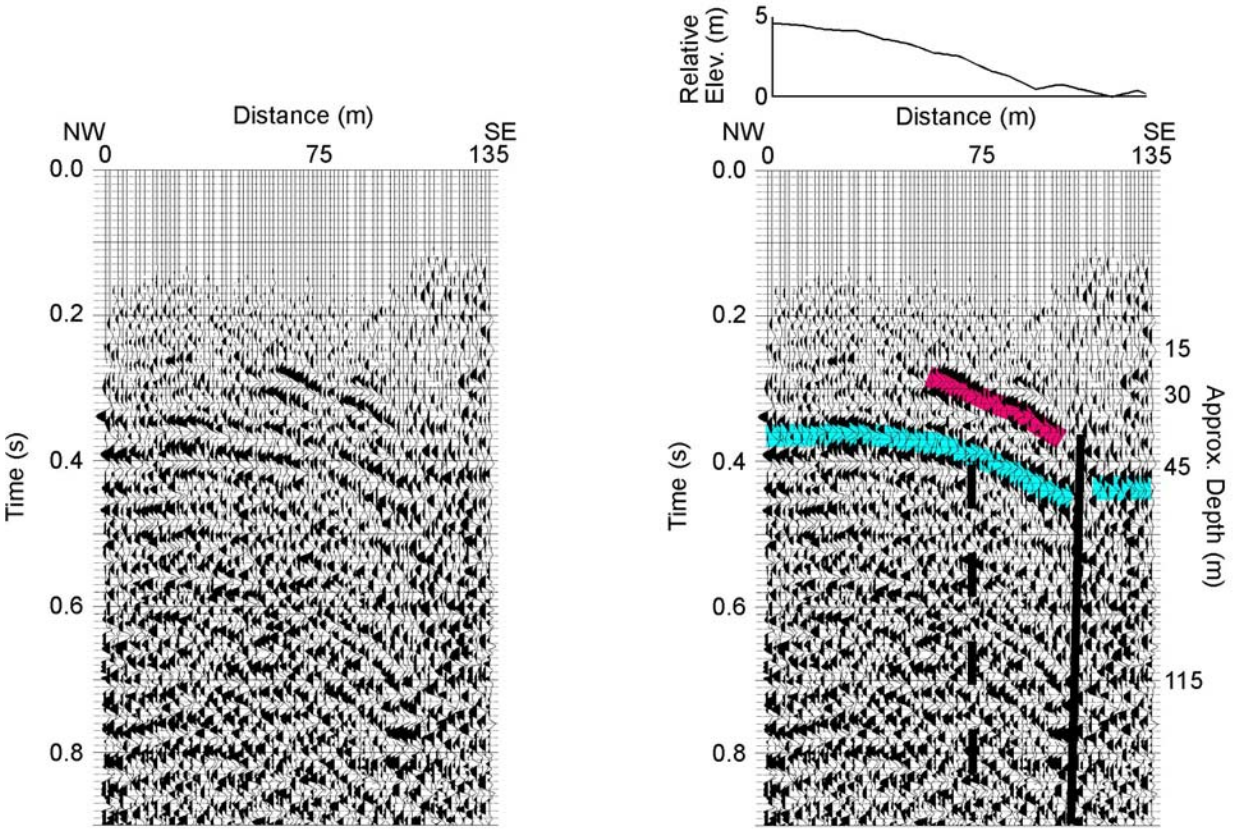

Figure 2. Uninterpreted and interpreted shear-wave seismic reflection profile (BC-1) across the Big Creek escarpment (see Figure 1 for location).

An additional S-wave reflection profile (BC-2) was acquired to better characterize near-surface deformation associated with the Big Creek escarpment. The profile is east of BC-1 where the escarpment diverts from its parallel relationship with the Big Creek valley and bends anomalously to the east (see Figure 1 for location). The purpose of the profile was to determine if the east-trending scarp segment is tectonic or represents a fluvial terrace. A 24-channel engineering seismograph was used to collect approximately 0.3 km of SH-wave data across the scarp. The seismic profile was shot using a split-spread geometry with 3-m shotpoint spacings and 1.5-m source offset. Seismic energy was generated by five horizontal impacts of a 1.8-kg sledgehammer on a 4.5-kg steel I-beam oriented perpendicular to the spread. Again, processing followed a standard flow and emphasized static corrections and velocity analysis. The 12-fold stacked

profile, with a preliminary interpretation, is shown in Figure 3. The profile exhibits strong, continuous, reflections at depths between 30-50 m (probably associated with the Quaternary-Tertiary boundary). The reflections are disrupted by a 50-m-wide fault zone coincident with the south-facing scarp. The fault zone is interpreted based on seismic amplitude variations, offset reflections, and the presence of strong diffracted energy (associated with the boundaries of the fault zone). Separation across the fault zone appears to be up-to-the-south, although topographic relief along the line is higher on the north. Therefore, the fault zone has likely experienced structural inversion during late Tertiary or Quaternary time.

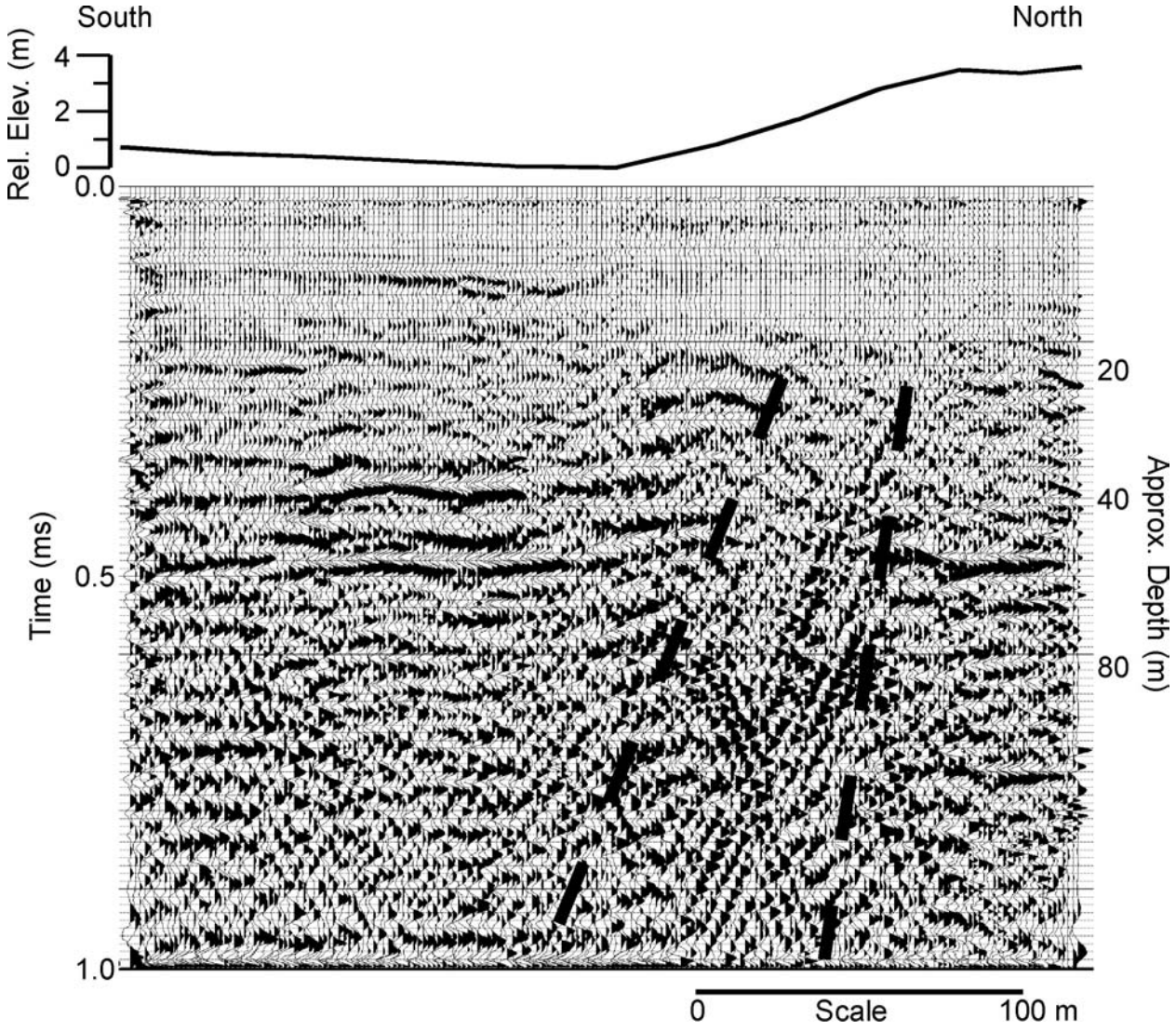

Figure 3. Shear-wave seismic reflection profile (BC-2) across the eastern Big Creek escarpment (see Figure 1 for location) with a preliminary interpretation showing a high-angle fault zone beneath the scarp.

Non-technical Summary

Shallow seismic reflection profiling has been the primary subsurface method used to identify, characterize, and evaluate the significance of near-surface tectonic deformation in the Lower Mississippi Valley. This research project is investigating the shallow geologic structure of the Big Creek Fault Zone (BSFZ), in eastern Arkansas, and its possible northeast extension into the Memphis metropolitan area using shear-wave seismic reflection profiling. The results of this work will allow a detailed evaluation of potential earthquake hazards associated with near-surface faults of the BCFZ.

Reports Published

Harris, J. B., Berman, S. A., Beard, W. C., Street, R. L., and Cox, R. T., 1998, Shallow seismic reflection investigations of neotectonic activity in the Lower Mississippi Valley: **68th Annual International Meeting of the Society of Exploration Geophysicists, Expanded Abstracts**, 848-851.

Harris, J. B., Cox, R. T., Berman, S. A., and Cole, B. W., 2000, Shallow seismic reflection imaging of the Big Creek Fault Zone in the Lower Mississippi Valley**: Geological Society of America, 2000 Annual Meeting, Abstracts with Programs**, p. A-56.

Harris, J. B., Cox, R. T., Berman, S. A., and Cole, B. W., 2001, Shallow seismic reflection imaging of the Big Creek Fault Zone: Implications for seismic hazard in northwest Mississippi: **Journal of the Mississippi Academy of Sciences**, v. 46, n. 1, p. 37.

Harris, J. B. and Woolery, E. W., 2001, Application of shallow seismic reflection methods in neotectonic studies: Observations on data acquisition, processing, and interpretation: **Geological Society of America, 2001 Annual Meeting, Abstracts with Programs**, November 5-8, 2001, Boston, Massachusetts.

Seismic Data Availability

Upon completion of the project, the seismic data (and associated field notes) will be made available in digital format (processed or unprocessed) by contacting:

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